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**RESEARCH AND DEVELOPMENT  
OF THE  
TRAINING IMPACT DECISION SYSTEM (TIDES):  
A REPORT AND ANNOTATED BIBLIOGRAPHY**

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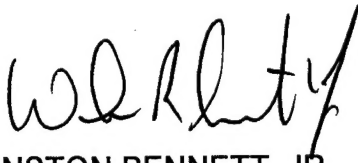
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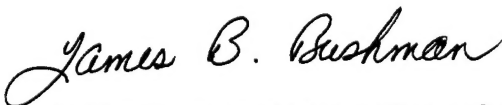
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## PREFACE

This paper is an introduction and general overview of the Training Impact Decision System (TIDES) as a decision support system (DSS) for use by Air Force decision makers involved with critical manpower, personnel, and training decisions. This report describes work currently underway under contracts F33615-89-C-0001 and F41624-93-C-5009 and briefly highlights previous activities conducted as part of earlier exploratory research and development efforts such as the Training Decisions System and Training Decisions Modeling Technologies. For more detailed technical information, see the publications referenced in this document, the TIDES specifications documents, or the references noted in Appendix A.

A shorter version of this paper (Grimes, Wimpee, Bennett, & Mitchell, 1994) was presented by Lt Col Wimpee at the 1994 Symposium on Human Interaction on Complex Systems, North Carolina A&T State University, Greensboro, NC, in September 1994.

Most of the conceptual design, mathematical modeling, and initial software development involved in this series of Training Decisions projects, was the work of the late **Dr. DAVID S. VAUGHAN (25 November 1949 - 15 January 1994)**, McDonnell Douglas Corporation. It is with sincere gratitude for his outstanding contributions that this work continues.

## SUMMARY

This report documents continuing research and application of a decision support system (DSS) by the Armstrong Laboratory, Human Resources Directorate, under contracts F33615-89-C-0001 and F41624-93-C-5009. This DSS is the Training Impact Decision System (TIDES), a computer-based system specifically designed to support key planners and decision makers (functional managers at the Air Staff or Major Command, training managers, etc.) for a career specialty (occupation). The TIDES was developed to extend task-based job analysis to model utilization and training (U&T) programs and quantify specialty training requirements, including on-the-job training (OJT). This type of career field modeling facilitates more systematic consideration of personnel utilization factors, training costs, resource requirements, training capacities of units (base-level organizations) and managers preferences in U&T Workshops where career field decision makers determine the optimal allocation of personnel and training resources.

## INTRODUCTION

Human Resources Management (HRM) and other organizational decisions are often made for a desired effect on the profit and loss statement without regard to their potential impacts on other HRM programs such as selection, placement, training, or occupational structures. Such HRM decisions can be modeled in terms of possible changes in job content and changes in training requirements. Such models can be quantified in order to predict the impact of the changes on both formal and on-the-job training (OJT) programs; ultimately these impacts must be assessed in terms of costs and organizational training capacities. This type of occupational modeling also permits estimation of the costs of training on-the-job which previously have not been visible to most managers or trainers. By making such hidden costs visible and by quantifying the impact of various proposed changes, such modeling efforts can support managers in making more realistic and cost-effective decisions (Rueter, Feldsott, & Vaughan, 1989; Mitchell, Yadrick, & Bennett, 1993).

Training management and planning have to be an integral part of any large organization. The very sizable, largely hidden costs of OJT make management of such training very critical. This is a problem of some magnitude which has only recently been recognized in the civilian literature. The American Society for Training & Development (ASTD) and the U.S. Department of Labor (DOL) estimate that employers in the U.S. "spend \$30 billion a year on formal training and approximately \$180 billion on informal OJT (ASTD, 1988)." Clearly, any improvement in the management of training (including OJT) has the potential for significant savings and substantially enhanced productivity (Campbell, Dunnette, Lawler, & Weick, 1970).

At the same time, recent developments in occupational analysis and training research, as well as in decision making processes, have created new opportunities for optimizing job training (Mitchell, Ruck, & Driskill, 1988). Such developments include the recent emergence of the Instructional System Development (ISD) process as a systematic approach to defining educational and training objectives for making and coordinating major training decisions (Eschenbrenner, DeVries, Miller & Ruck, 1980; Vaughan, Mitchell, Yadrick, Perrin, Knight, Eschenbrenner, Rueter, & Feldsott, 1989). Such innovative procedural changes also make obvious a need for technologically-advanced data generation, analysis, and evaluation to support military decision makers.

## BACKGROUND

### Decision Support Systems

Recent technological developments in personal computers, computer networks, and computer-based models have made possible a level of interactive support for decision makers never before possible (Carlson, 1983). Decision support for management decision making implies the use of computers to: 1) assist managers in their decision processes in semi-structured tasks; 2) support, rather than replace, managerial judgment; and 3) improve the effectiveness of decision making rather than its efficiency (Keen and Scott Morton, 1978). Additionally, Sprague and Carlson (1982) observed that decision support systems (DSSs) may be defined by their capabilities in several critical areas, including the following: 1) they tend to be aimed at the less well structured, under-specified problems that upper-level managers typically face; 2) they attempt to combine the

use of models or analytic techniques with traditional data access and retrieval functions; 3) they specifically focus on features that make them easy to use by non-computer people in an interactive mode; and 4) they emphasize flexibility and adaptability to accommodate changes in the environment and decision-making approach of the user.

To be useful to Air Force decision makers, a DSS should make maximum use of existing data sources, should permit collection or estimation of new data when needed, and should organize or structure the information in ways which are meaningful to those involved. Fortunately, the Air Force has a number of on-going programs which generate information which can be and are used in making manpower, personnel, and training decisions.

### **Air Force Job Analysis**

Over the last three decades, the Air Force has developed a task-based approach for studying Air Force occupations (Christal, 1974; Morsh, 1964). As part of this occupational analysis (OA) process, tasks are defined by job experts in their own technical terminology. Several kinds of data are collected from job incumbents and supervisors on these tasks. For example incumbents provide information about tasks they perform in their present jobs and the relative amount of their job time spent performing such tasks. Senior technicians rate specialty tasks as to their relative difficulty to learn and needed emphasis in initial skills training. Resulting data can be used to examine the variety of specialized jobs within an occupation, to assess how jobs change at advanced skill levels, and to review official occupational descriptions and initial skills training programs (Christal & Weissmuller, 1988; Mitchell, et al., 1988).

### **Air Force Training**

The Air Force currently has an extensive, very highly developed training system which prepares individuals to perform a wide variety of jobs; most of the Air Force training programs are organized by specialty (occupation). There are four primary settings for most Air Force training; the first is formal classroom instruction. A second major category is supervised on-the-job training (OJT). Third, there are "hands-on" training programs (laboratory, mobile training teams, field exercises, etc.) where equipment- or system-specific training is conducted, quite often at or near the work site. The final type of training involves self-study (correspondence, self-paced computer lessons, etc) courses. [A number of other training delivery techniques might also be considered for specific occupations (distance learning, etc.); these can be grouped into the four broad categories listed above or considered as separate training settings.]

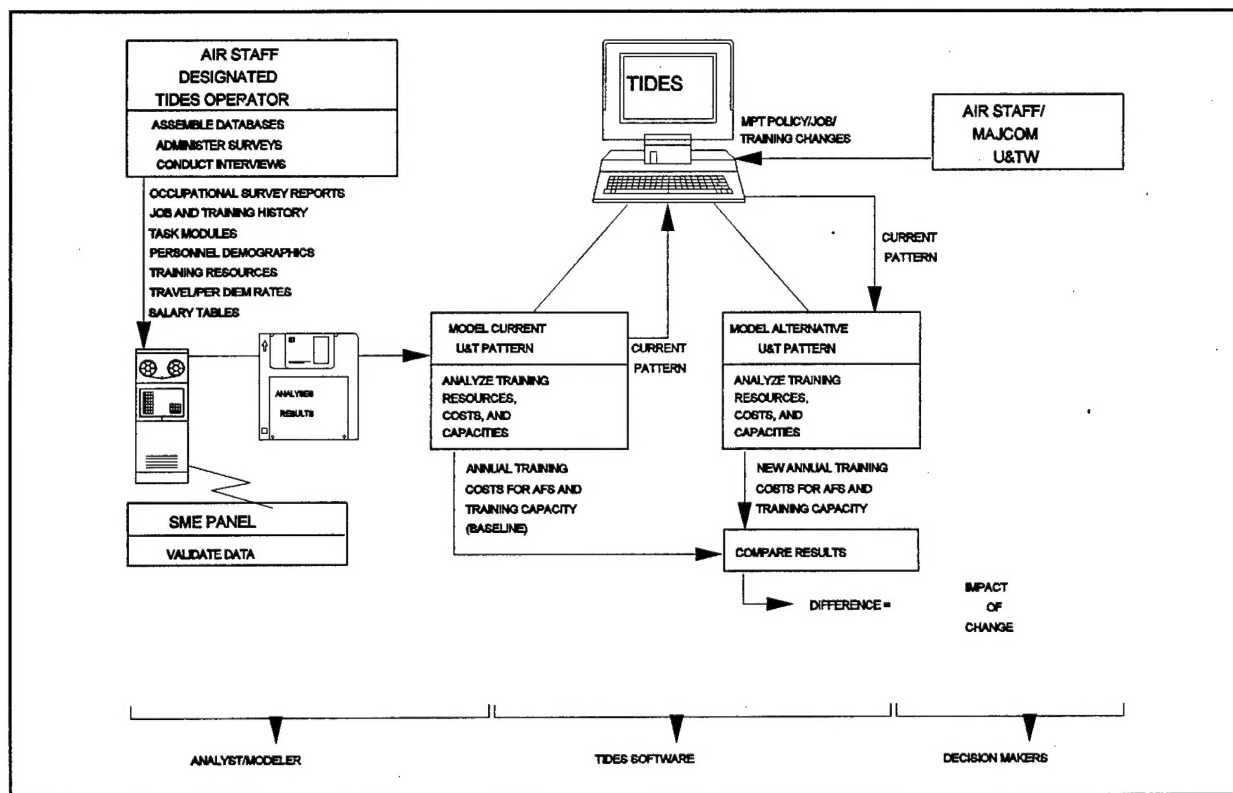
To make good decisions about the training needed for an occupation or system, decision makers must develop a framework or "model" as a means of visualizing and understanding the jobs and training programs of the occupation or system under consideration. The framework or "model" also includes the occupation's technical training and general professional development requirements, as well as the relative costs and payoffs of various training configurations. Such a "model" provides a concise summary of the current status of the occupation, creates a common "language" for discussion or negotiation, and forms the baseline against which various alternative proposals for refinements to training programs, changes of the job structure, or reallocation of personnel and resources, can be evaluated (Ruck & Birdleough, 1977; Chin, Lamb, Bennett, & Vaughan, 1992). Therefore, a decision support system, which incorporates a modeling capability,

is needed to provide information to key decision makers to help them assess potential outcomes of the various alternative proposals (Mitchell, Vaughan, Knight, Rueter, Fast, Haynes, & Bennett, 1992).

## TRAINING IMPACT DECISION SYSTEM (TIDES)

### Technology Description

The TIDES technology helps Air Force training managers balance an occupation's training needs versus resources and requirements to optimize training management throughout the entire career of an individual or group of individuals (this includes all training, formal and informal, as well as all jobs an individual could perform throughout their career with the Air Force). Such specialized groups of individuals have different training needs, and substantial economies are possible through tailored training. TIDES technology provides analysts and decision makers with a tool to systematically gather, integrate, and analyze information about jobs, tasks, career assignments, personnel flows, and technical training programs within an Air Force occupation (see Figure 1).



**Figure 1. TIDES Operational Concept - Modeling Current & Alternative Utilization and Training Patterns.**

By dynamically modeling an occupation's career flow patterns, the TIDES technology provides a "what if" capability to assess the long-term impact of current and future constraints stemming from changing training, personnel and fiscal policies and resources. TIDES analyses also aid decision makers in determining what tasks associated with an occupation to train, when to provide that training (at what career points), and the method best suited for that type of training (Ruck, 1982; Vaughan, Yadrick, Perrin, Cooley, Duntelman, Clark, & Rueter, 1984).

## **TIDES Data Collection**

As part of the TIDES data collection process, analysts identify the resource requirements needed to conduct the necessary type of training. To collect this information, groups of subject matter experts (SMEs) within an Air Force occupational area are assembled. These SMEs first identify the jobs and training courses for a particular Air Force occupation. Next, they describe the jobs and training courses which are identified for the occupation.

The TIDES technology uses task modules (TMs), groups of tasks that share similar characteristics (e.g., equipment, skills, etc.). These tasks are collected as part of the Air Force occupational process. The current training course and job assignment flows must be identified in order to build a model of the utilization and training (U&T) pattern for the occupation. SMEs also validate the components of the model--the positions within the occupation (jobs), skills and experience required to perform those jobs, and number of years a person is likely to hold that job. Finally, the SMEs identify locations that are considered to be "typical" or representative sites to assess typical OJT programs. This information is used as a baseline for future comparisons. This allows TIDES to describe each of the training courses and training patterns, within an occupation, in terms of cost and resource requirements.

Cost estimates for conducting training are obtained by collecting information on travel to and from the training sites and the per diem cost while students attend the training. Information is also obtained on the variable cost per student per formal training site, as well as the number of hours and wage rates of individuals (trainers & trainees) involved in on-the-job training. All cost information is gathered for each TM per each training setting. In addition to the detailed information related to cost, information is also collected on the number of hours required to train individuals to certain levels of proficiency (learning curves) by TM and training setting (Perrin, Knight, Mitchell, Vaughan, & Yadrick, 1988). Using this information, tradeoffs between different training settings with respect to a given level of desired performance can be identified. For example, if a portion of training were moved from one setting to another, the TIDES can estimate the approximate amount of time and expense involved in each setting by desired proficiency level.

All of these types of information are synthesized into a set of TIDES files which quantitatively model the current Utilization and Training (U&T) pattern of a career field (left half of Figure 1). The U&T simulation is then run and reports generated on the total annual training costs for the AFS and training capacity (including identifying critical constraints). Such summary data and reports become the "baseline" against which any proposed changes to specialty jobs and training programs can be assessed.

## **TIDES "What If" Modeling**

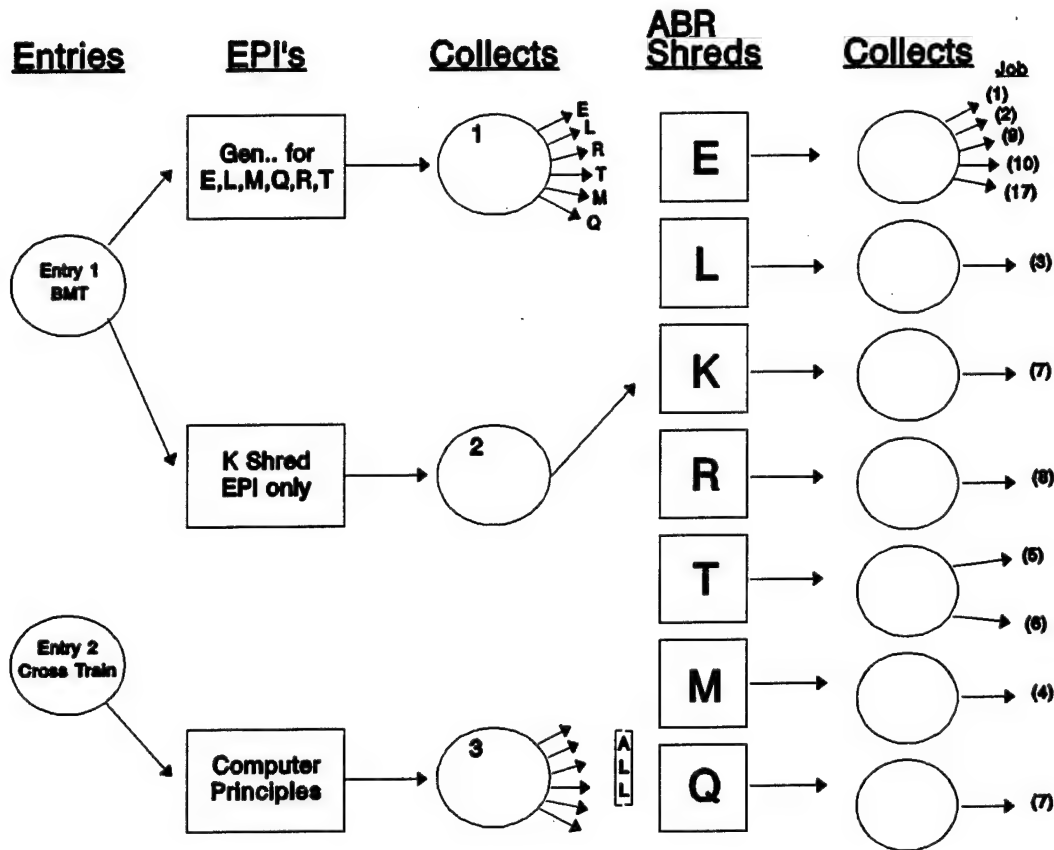
In general, TIDES "what if" modeling involves creating alternative job and training patterns reflecting manpower, personnel, and training policy options of interest. This can be done by a TIDES analyst or modeler, or by Air Force decision makers, such as the functional manager for the AFS at the Air Staff or Major Command, or in a group session such as at a U&T Workshop (right side of Figure 1). Once an alternative is specified, the model is run on the alternative job and training patterns, and model results are compared to those for the baseline model (the current job and training pattern). In creating an alternative job and training pattern, new values are specified for certain input or independent variables in the model (Vaughan, et al., 1989).

While such relationships may have been intuitively obvious to some managers in the past, it is only now that such relationships can be quantified and reported to support and justify necessary training investment decisions. The types of information and data displays provided in a decision support system such as the TIDES can be crucial for helping managers and other decision makers improve their understanding of the potential impact or consequences of their decisions. Further, such a system will also help them document the rationale for such decisions, and defend such decisions to higher levels of command within the Department of Defense and to Congress.

## **TIDES Success**

During the development of TIDES, tests were run on several Air Force occupations, ranging from fairly homogeneous career fields, such as the B-1 Avionics Test Station (two jobs plus supervisors), to very structured specialties, such as Security and Law Enforcement (85 job variations), to complex electronics career fields, such as the Radar and Inertial Navigation Systems technicians (many distinct jobs by equipment system, each with its own advanced skills training course). Occupations with high volume of trainees and complex tasks were analyzed.

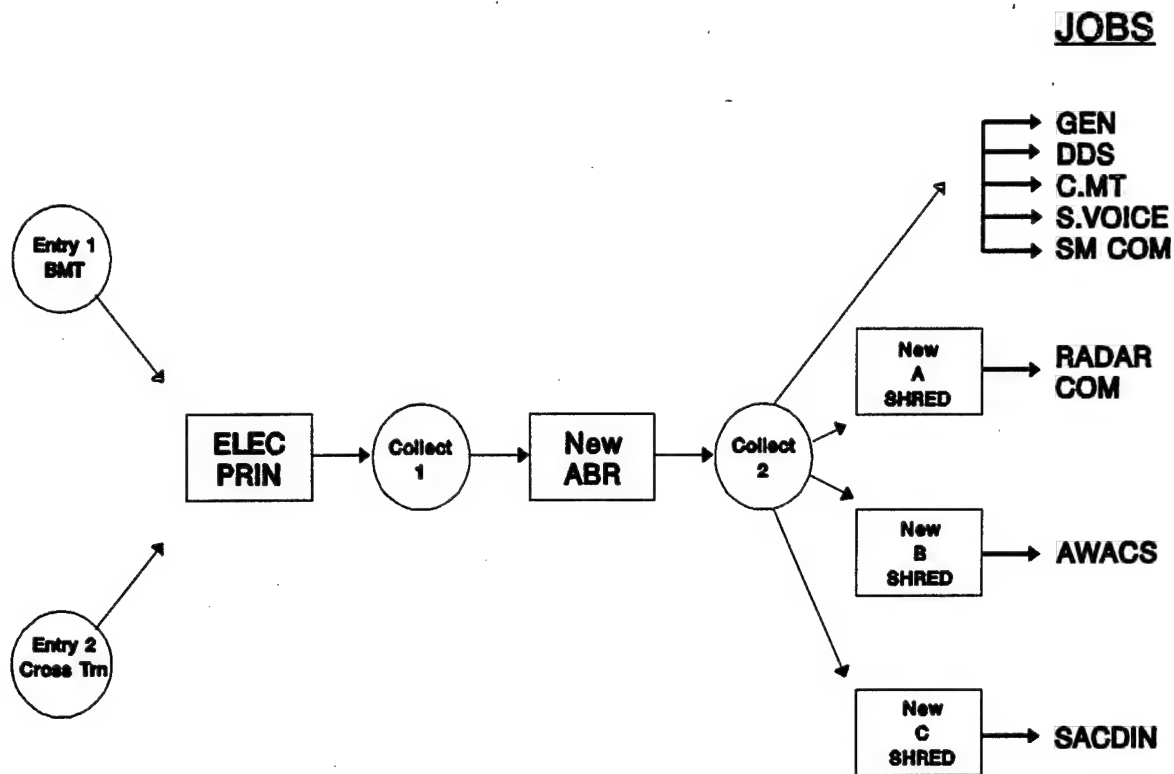
One occupation studied dealt with sophisticated computers and switching equipment systems maintenance. The equipment was so complex that the training and personnel were specialized by the type of equipment they maintained. As such, this occupation had a common core but seven different major types of equipment systems, each with its own training program and jobs (see Figure 2).



**Figure 2. Current Electronic Computer and Switching Systems Training Programs and Jobs.**

Problems were beginning to show up at a senior level; technicians were so specialized that they knew little about the entire occupation. Therefore, when decisions were being made, certain specialty areas may have been underemphasized due to the lack of the decision makers' experience with some equipment.

TIDES was used to examine various ways to collapse the seven separate tracks into a smaller set of subspecialties; the final consensus among representatives of the various constituencies was for a common (general) track plus three specialized tracks. The group examining the problem (a Utilization & Training Workshop) reached this conclusion by assessing the similarities between the subspecialties. It was discovered that even though the equipment was different, the differences were fewer than the similarities. This finding suggested some simplification of the classification structure and training programs (see Figure 3).

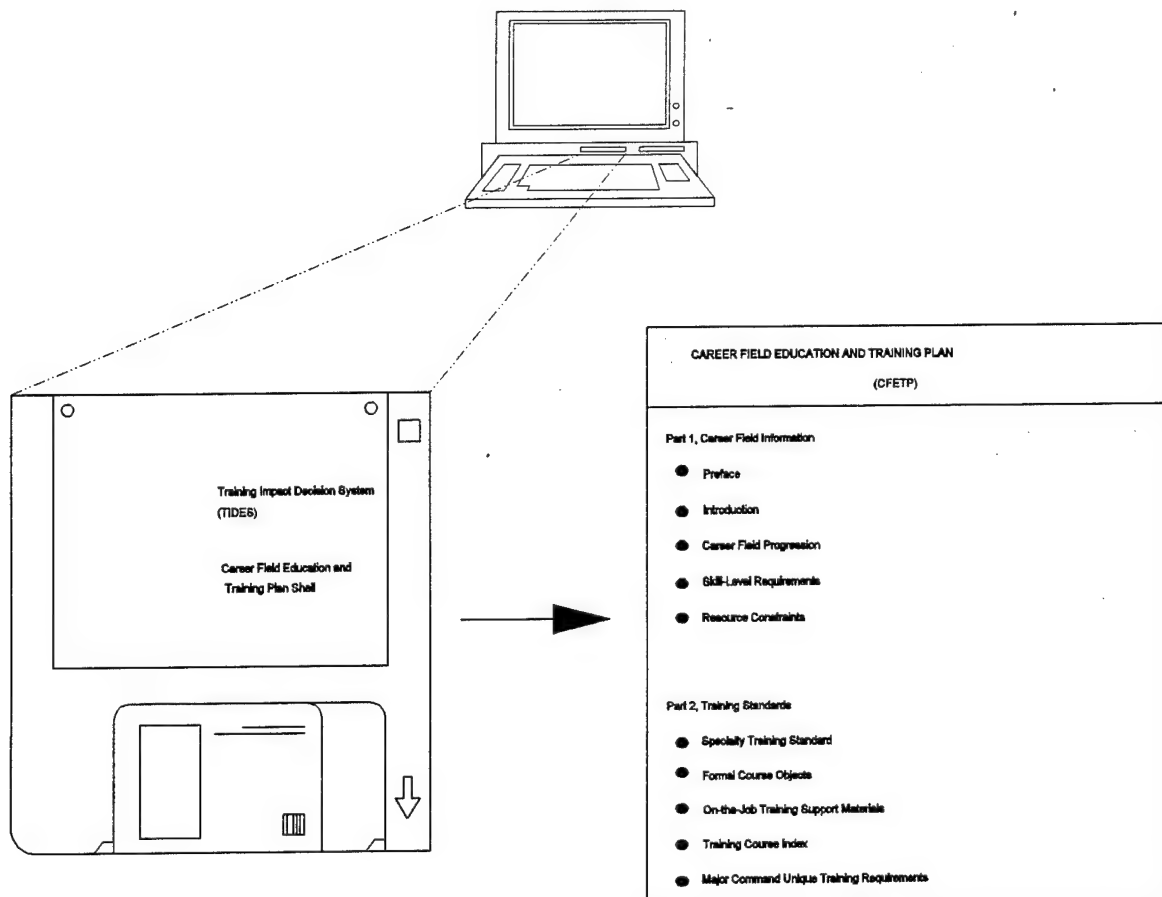


**Figure 3. Proposed New Job and Training Structure for Electronic Computer and Switching Systems Maintenance Specialty.**

This consolidation reduced the overhead needed to manage the occupation and will increase the experience base for future senior technicians. Most importantly, when combined with other Air Force personnel policy changes, including increasing average assignment times from 32 to 48 months, there was a potential reduction of \$1.7 million in annual training costs, even though each new individual would receive more complete training than in the past.

### **Career Field Planning Documents**

In addition to the TIDES "what if" capability, the software also contains a shell for developing written guidance for specialty planning documents. Such documents are called Career Field Education and Training Plans (CFETPs). CFETPs identify normal career progression for specialties, define the appropriate skills necessary and level of proficiency for each major category of skill, courses available and any resource constraints for future learning. These documents usually take considerable time and energy to compile. They must be completed by SMEs in the specialty, typically four or five people work on it for several days. Using the TIDES CFETP software shell (see Figure 4), subject matter experts can produce a draft plan, often in a single day. The shell provides a standardized format, help screens, examples of text which can be used if they desire and general instructions on how to complete the document.



**Figure 4. Career Field Education & Training Plan (CFETP) Software Shell**

### **TIDES Current Efforts**

The TIDES technology is currently running on a mainframe computer, utilizing flat-file data bases. It is not particularly user friendly in its current form. Enhancements currently being developed will make TIDES run on a 386 or better DOS-based microcomputer. Additionally, the technology is being made more user friendly by utilizing relational data bases. It is envisioned that once an initial TIDES data base for a specialty has been developed, TIDES users will be able to sit at their personal computers, formulate and run various scenarios weighing the alternatives, and forecast the impacts of decisions before they become policy.

Additional efforts are underway to experiment using the TIDES technology in occupations utilizing civilians as well as military personnel. Department of Defense civilians have different mobility requirements, job descriptions, and career structures than military personnel performing the same jobs. It is expected the TIDES can be applicable to civilian as well as military occupations. Therefore, it is likely that a decision support system such as TIDES could be

applied in large civilian organizations with high volume, expensive training programs. The TIDES would be extremely useful in their training, personnel policy, and budgetary decision making.

Portions of the TIDES technology may also be applicable to Officer specialties. One project underway will adapt the Career Field Education and Training Plan (CFETP) document shells for use with officer specialties. Eventually, enlisted, officer and civilian personnel working in a particular occupation or functional area may all be covered by a common CFETP. This was one of the long-range objectives formulated as a result of the Air Force Chief of Staff's Year of Training Initiative.

## **SUMMARY**

The TIDES technology is a computer-based decision support system embodying a new technology for modeling occupations. It is a powerful tool for strategic manpower, personnel, and training planning, and represents a major advance in occupational analysis technology and training requirements planning. The TIDES provides significant new data analysis and modeling for occupations including comprehensive portrayals of existing jobs and training programs. The TIDES goes beyond simply describing the current state of affairs to permit exploration of hypothetical scenarios. Although the system was designed primarily for use by training decision makers, the integrated TIDES approach has considerable potential for promoting the eventual integration of human resources management--manpower, personnel, training, and budgeting with other human resources planning functions.

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## APPENDIX A - TDS & TIDES TECHNOLOGIES: AN ANNOTATED BIBLIOGRAPHY <sup>1</sup>

Ruck, H. W. (1982, February). Research and development of a training decisions system. *Proceedings of the Society for Applied Learning Technology*. Orlando, FL.

A conceptual overview of a planned line of research and development, to explore the possibility of helping Air Force managers who make critical decisions in the area of training to make better decisions, through the use of existing data or by collecting new information. A critical element of this R&D will be an attempt to determine the costs of on-the-job training.

Vaughan, D. S., Yadrick, R. M., Perrin, B. M., & Mitchell, J. L. (1985, May). Clustering tasks into training modules in the Air Force training decisions system. *Proceedings of the Fifth International Occupational Analysts Workshop* (pp. 126-145). Randolph AFB, TX: USAF Occupational Measurement Center.

A report of on-going efforts to develop methods for finding groups of tasks which can be trained together; i.e., have similar skill and knowledge requirements, are performed by the same people, or share other similar characteristics. This initial investigation included alternative methods for measuring task characteristics, assessing similarities among tasks, and identifying clusters of tasks.

Garcia, S. K. (1985, October). Development of an Air Force training decisions system. *Proceedings of the 27th Annual Conference of the Military Testing Association* (pp. 262-264). San Diego, CA: Naval Personnel Research and Development Center.

An overview of to the Training Decisions System R&D and description of the TDS subsystems; Task Characteristics Subsystem (TCS), Field Utilization Subsystem (FUS), Resource/Cost Subsystem (RCS), and Integration/Optimization Subsystem (IOS).

Perrin, B. M., Vaughan, D. S., Yadrick, R. M., & Mitchell, J. L. (1985, October). Defining task training modules: copformance clustering. *Proceedings of the 27th Annual Conference of the Military Testing Association* (pp. 265-270). San Diego, CA: Naval Personnel Research and Development Center.

This study compares copformance clustering of tasks with task groupings made by groups of subject-matter experts (SMEs), using the Jaccard and the Fowlkes & Mallows statistics (corrected versions of the RAND statistic). Results suggest that copformance clustering agrees with SME clustering at least as well as one group of SMEs agree with another SME group. Thus, this approach appears promising for generating Task Modules (TMs) which may be useful in the TDS R&D.

<sup>1</sup> The papers and presentations in Appendices A and B are listed in chronological order. [As of: 11/95]

Yadrick, R. M., Vaughan, D. S., Perrin, B. M., & Mitchell, J. L. (1985, October). Evaluating task training modules: SME clustering and comparisons. *Proceedings of the 27th Annual Conference of the Military Testing Association* (pp. 271-275). San Diego, California: Naval Personnel Research and Development Center.

This study builds on the previous one by comparing copformance clusters with those of SME groups using different procedures; one group starting from copformance piles of cards (one task per card) and a second group starting from piles of cards sorted by Specialty Training Standard (STS) paragraph. Subsequently the two SME groups negotiated to consensus on how the tasks should be group, which provides a standard for comparison. Results suggest TMs constructed by a single group of SMEs may not be stable, but perhaps some combination of copformance clustering with SME review of TMs may be needed.

Mitchell, J. L., & Phalen, W. J. (1985, October). Non-hierarchical clustering of Air Force jobs and tasks. *Proceedings of the 27th Annual Conference of the Military Testing Association* (pp. 276-281). San Diego, California: Naval Personnel Research and Development Center.

In a typical CODAP study, 5 to 20 percent of the total cases may fall outside of the identified job types. An attempt was made to use Non-hierarchical reclustering of job types to refine the identified job groups in a study of Security and Law Enforcement personnel (AFS 811XX). Preliminary results strongly suggest that the Non-hierarchical clustering process has considerable potential in refining the typical occupational analysis process, and increasing the coverage of identified job types to 95 percent of cases or better.

Mitchell, J. L., Vaughan, D. S., Yadrick, R. M., & Collins, D. L. (1987, May). New methods for portraying dynamic training and job patterns within Air Force specialties. *Proceedings of the Sixth International Occupational Analysts' Workshop* (pp. 103-113). San Antonio, TX: USAF Occupational Measurement Center.

The typical occupational analysis report identifies job types based on CODAP hierarchical clustering based on the similarity of tasks performed and time spent on those tasks. The job types include cases with similar profiles regardless of time-in-service or time-in-career field, which is a rather static, two-dimensional perspective. Resorting job types members by total active federal months in service (TAFMS) categories results in a more dynamic picture of job type members, as they are dispersed over the span of a typical career (20+ years of service).

Collins, D. L., Hernandez, J. M., Ruck, H. W., Vaughan, D. S., Mitchell, J. L., & Rueter, F. H. (1987, August). *Training decisions system: Overview, design, and data requirements* (AFHRL-TP-87-25). Brooks AFB, TX: Training Systems Division, Air Force Human Resources Laboratory.

The Training Decisions System (TDS) research and development effort evolved from a recognition by HQ ATC and USAF/DPPT that (a) independent decisions were being made by different agencies within the manpower, personnel, and training (MPT) communities; (b) there was no way to proactively estimate what the impact of various training options would be; and (c) there were no comprehensive, readily accessible cost data regarding OJT. MPT decisions--although they are the best possible given the available information--could benefit significantly from an accurate data base and modeling capability oriented toward the macro-level decision maker. This report provides an overview of the TDS R&D effort and the current design of this system.

Perrin, B. M., Vaughan, D. S., Mitchell, J. L., Collins, D. L., & Ruck, H. W. (1987, October). Effects of data collection format on occupational analysis task factor ratings. *Proceedings of the 29th Annual Conference of the Military Testing Association* (pp. 96-100). Ottawa, Ontario, Canada: Directorate of Military Occupational Structures, Canadian National Defence Headquarters.

This study compared collecting multiple task factor ratings on a single response page versus collecting the same ratings independently. The correlations among the task factor ratings was systematically higher when collecting on the same form than when collected via separate instruments. These findings suggest that task factor ratings should be collected separately in both research and operational settings.

Ruck, H. W., & Collins, D. L. (1987, October). A microcomputer simulation of an Air Force training decisions system. *Proceedings of the 29th Annual Conference of the Military Testing Association* (pp. 158-163). Ottawa, Ontario, Canada: Directorate of Military Occupational Structures, Canadian National Defence Headquarters.

The results of a four-year, AFHRL exploratory 6.2 R&D effort to develop a computer-based Training Decisions System (TDS) are discussed as is a microcomputer simulation of the system. TDS displays include modeling of the current and alternative Utilization & Training patterns as well as allocations of training to various training settings. The simulation is a menu-driven, self-paced system which provides users with options to select data displays and possible optimization outcomes. The examples of products illustrate the prototype system as designed to operate on the AFHRL mainframe computer in a batch processing mode. The TDS is designed to interface with CODAP and other AFHRL systems, to minimize the development of new TDS software.

Mitchell, J. L., Ruck, H. W., & Driskill, W. E. (1988). Task-based training program development. In Gael, Ed (Ed.), *The Job Analysis Handbook for Business, Industry, and Government* (Volume 1; pp.205-215. New York, NY: John Wiley & Sons.

The TDS is mentioned in this overview chapter as one of the outcomes of the task-based approach to job analysis, and as a natural evolution of the Training Emphasis R&D which attempted to prioritize occupational tasks in terms of their priority for training.

Yadrick, R. M., Knight, J. R., Mitchell, J. L., Vaughan, D. S., & Perrin, B. M. (1988, July). *Training decisions system: Development of the field utilization subsystem* (AFHRL-TR-88-7). Brooks AFB, TX: Training Systems Division, Air Force Human Resources Laboratory.

A summary report of the initial TDS R&D project with respect to the development of various types of utilization and training patterns (U&TPs) to "model" Air Force specialties (AFSs). The Field Utilization Subsystem (FUS) has three major components: (1) the current U&TP component to describe the AFS, (2) Alternative U&TP component to possible changes in the AFS as alternative U&TPs, and (3) the Management Preferences component to collect and display the opinions of various functional and training managers among the various U&TPs.

Perrin, B. M., Knight, J. R., Mitchell, J. L., Vaughan, D. S., & Yadrick, R. M. (1988, September). *Training decisions system: Development of the task characteristics subsystem* (AFHRL-TR-88-15, AD-A199 094). Brooks AFB, TX: Training Systems Division, Air Force Human Resources Laboratory.

This report documents the research undertaken in initial development of the Task Characteristics Subsystem (TCS), one of four basic subsystems of the prototype Training Decisions System (TDS). The TCS addresses what tasks are required to be trained and where (training settings) to allocate those requirements. This two-component involves first the construction of task training modules (TMs) from occupational survey (OS) data. The second component allocates TMS to various training settings, such as formal classroom training, on-the-job training (OJT), and others, and determines levels of proficiency achieved by setting. A number of methodologies were tested for the clustering of OS tasks into TMS. Some TMS were also subjected to task analysis to assess homogeneity of required skills and knowledge. New Comprehensive Occupational Data Analysis Programs (CODAP) routines were developed and have been implemented. Three measures of T.M.-by-setting proficiency were pilot tested. Guidelines for applying procedures developed in this R&D were also developed.

Mitchell, J. L., Vaughan, D. S., Yadrick, R. M., Collins, D. L., & Hernandez, J. M. (1988, September). *The Air Force training decisions system: Modeling job and training flows* (AFHRL-TP-88-12). Brooks AFB, TX: Training Systems Division, Air Force Human Resources Laboratory.

The Training Decisions System (TDS) uses information about clusters of related tasks (Task Training Modules or TMS), a dynamic model of specialty job flows and training programs, and data on unit training capacities and costs, to compare job and training options. In the prototype TDS development, graphic and mathematical models of four Air Force specialties and several alternative Utilization and Training (U&T) Patterns were created. Managers preferences for the various alternatives were collected through a survey questionnaire. Results were highly favorable; analysis indicated a high degree of agreement among raters. A *post hoc* analysis suggested some systematic differences of opinion among subgroups of raters. Managers evaluated the project very favorably and indicated the models had successfully captured and communicated the U&T Patterns of the four occupations.

Vaughan, D. S. (1988, November). Overview of the training decisions system: Results and products. In the symposium, *The Air Force Training Decisions System: R&D Results* (W. R. Bennett, Chair). *Proceedings of the 30th Annual Conference of the Military Testing Association* (pp. 779-784). Arlington, Virginia: Army Research Institute.

Overview of the technical approach and significant outcomes of the TDS R&D at the conclusion of the initial R&D effort. The approach used in TDS is to model each problem or potential solution as an independent Utilization and Training Pattern (U&TP); once a problem or potential solution has been identified, it is expressed in terms or quantities of the TCS (i.e., task modules, training settings, and allocation curves). The FUS modeling capability is used to translate the potential solution into modifications of the U&TP data base for the AFS; that is as an alternative to the current U&TP files. FUS and RCS software are employed to generate products for each alternative and results, in the form of training costs and capacities are compared to baseline data by Air Force decision makers.

Perrin, B. M. & J. R. Knight (1988, November). The task characteristics subsystem: Allocating task modules to training settings. In the symposium, The Air Force Training Decisions System: R&D Results (W. R. Bennett, Chair). *Proceedings of the 30th Annual Conference of the Military Testing Association* (pp. 785-790). Arlington, Virginia: Army Research Institute.

The Task Characteristics Subsystem (TCS) provides data on training setting allocations and on task training modules (TMS). TMS are the basic building blocks of the TDS, in that all training courses and jobs are described in terms of TMS, and training costs are determined using T.M.-based procedures. Procedures for deriving TMS are described, as are data collection methods for deriving equations for relating training hours to required proficiency. Such functions (curves) permit examination of the possibilities of training in various training setting configurations, and for estimating on-the-job training (OJT) costs.

Mitchell, J. L., & Yadrick, R. M. (1988, November). The field utilization subsystem: Job and training pattern simulations. In the symposium, The Air Force Training Decisions System: R&D Results (W. R. Bennett, Chair). *Proceedings of the 30th Annual Conference of the Military Testing Association* (pp. 791-796). Arlington, Virginia: Army Research Institute.

The Field Utilization Subsystem (FUS) provides information for defining training and job assignment patterns, as well as information on management preferences for the current and plausible alternative approaches to training, assigning, and using airmen in a particular Air Force Specialty (AFS) over the span of their Air Force careers. The FUS consists of a Current U&T Pattern component, to describe the existing specialty, an Alternative U&T Pattern component to hypothesize one or more alternative configurations of jobs and training programs, and an FUS Flow Simulation program which quantifies the numbers of people involved on an annual basis.

Rueter, F. H. & Feldsott, S. (1988, November). Resource/cost subsystem: Estimating training capacities and costs. In the symposium, The Air Force Training Decisions System: R&D Results (W. R. Bennett, Chair). *Proceedings of the 30th Annual Conference of the Military Testing Association* (pp. 797-802). Arlington, Virginia: Army Research Institute.

The Resource\Cost Subsystem (RCS) was developed to prove three distinct, yet interrelated analytic capabilities: (1) determination of the types and amounts of resources required to provide training on each T.M. in each training setting, and estimate the amounts of those resources available for use at typical sites; (2) assess the capacities of sites to accommodate different volumes of training on different combinations of TMS in different training states, and (3) estimation of the variable costs that must be incurred in providing training on each T.M. in each training setting, and in providing particular volumes of training in specific training states.

Vaughan, D. S., & Eschenbrenner, A. J. (1988, November). Integration/optimization subsystem: An integrated modeling approach. In the symposium, The Air Force Training Decisions System: R&D Results (W. R. Bennett, Chair). *Proceedings of the 30th Annual Conference of the Military Testing Association* (pp. 803-808). Arlington, Virginia: Army Research Institute.

The Integration/Optimization Subsystem (IOS) ties together the other three TDS subsystems into one overall functional system. The interconnections of the subsystems provide the capacity to optimize measures derived from one subsystem relative to constraints obtained from the others, and simultaneously process data files derived from different subsystems. The IOS also provides the interface with users; that is, the subsystem receives all requests, calls appropriate data from the other subsystems or TDS files, and creates products to meet

the users' needs. In all of its functions, the IOS governs the interaction among the TDS subsystems and various data sources, and the relationship of the system with various types of users.

Ruck, H. W. (1988, November). Discussion of the TDS project. In the symposium, The Air Force Training Decisions System: R&D Results (W. R. Bennett, Chair). *Proceedings of the 30th Annual Conference of the Military Testing Association* (page 809), Arlington, Virginia: Army Research Institute.

The development of the Training Decisions System represents the culmination of a line of research which began in the mid-1970's, and which has progressed step-by-step to the present evolved, computer-based, decision support system. The TDS is designed primarily to provide Air Force decision makers with information in a form which will assist them in making critical decisions involving training. The operational concept involved is to be able to show decision makers some of the possible consequences of their decisions in specific quantitative terms, something which has never been done before. The very complex TDS challenge involved designing new methods to collect, aggregate, predict, and display Air Force specialty job and training data, including modeling alternative specialty patterns and estimation of capacities and costs for formal courses as well as on-the-job training (OJT).

Vaughan, D. S., Mitchell, J. L., Yadrick, R. M., Perrin, B. M., Knight, J. R., Eschenbrenner, A. J., Rueter, F. H., & Feldsott, S. (1989, June). *Research and Development of the Training Decisions System* (AFHRL-TR-88-50). Brooks AFB, TX: Training Systems Division, Air Force Human Resources Laboratory.

This document summarizes the R&D undertaken to develop the Training Decisions System (TDS). The TDS is a computer-based decision aid to be used in planning the what (training content), the where (technical school, Field Training Detachment, on-the-job training, or self-study), and the when (at what point in an airman's career) of training required for an Air Force specialty. Further, the TDS incorporates optimization strategies to allow training managers to ask "what if" questions related to current and possible future policy changes within the Air Force training environment. In addition, this report contains a brief conceptual overview of the three major data-based subsystems and the fourth integrating/optimization subsystem which compose the present TDS. Implications from recent trends in Air Force personnel and training policy that affect training management and planning, and a review of agencies within the Air Force which could support and use technologies such as the TDS are discussed. Finally, conclusions and recommendations for using TDS products in the operational Air Force, including a draft Air Force Regulation for implementing and maintaining the TDS, are presented.

Vaughan, D. S., & Lamb, T. A. (1989, November). Training decisions modeling outcomes: Conclusions and implications. In the Symposium (Ruck, H. W., Chair), The Air Force training decision system: Modeling management and policy issues for effective training. *Proceedings of the 31st Annual Conference of the Military Testing Association* (pp. 588-593). San Antonio, TX: Air Force Human Resources Laboratory and the USAF Occupational Measurement Center.

This presentation reviews and summarizes the Training Decisions System (TDS) analysis results from the previous presentations. The analysis process used to obtain these results is also reviewed. Overall conclusions are presented concerning the manpower, personnel, and training (MPT) policy issue that was the subject of those TDS analyses--a 25% reduction in travel-to-school (TDY-to-school) budgets. The TDS can also be used to examine many other types of training structure-related issues, as well as MPT-related issues. This wide span of issues that can be addressed and analyzed using TDS technology are described, and some examples are

provided. Finally, overall status and future directions for training decisions support research and application are discussed.

Knight, J. R., & Bennett, W. R. (1989, November). Utilization & training pattern simulation results. In the Symposium (Ruck, H. W., Chair), The Air Force training decision system: Modeling management and policy issues for effective training. *Proceedings of the 31st Annual Conference of the Military Testing Association* (pp. 570-575). San Antonio, TX: Air Force Human Resources Laboratory and the USAF Occupational Measurement Center.

To adequately model the flow of personnel through jobs and training programs, TDS employs a dynamic simulation approach, which gives an analyst the capability to vary specified values (i.e., number entering, assignment probabilities, attrition rates, etc.). Using the U&T Pattern Simulation (UTPSIM) program, a change such as a 25% reduction in TDY-to-School budget can be modeled by reducing the probability of attending Field Training Detachment (FTD) or Professional Military Education (PME) courses requiring travel. The UTPSIM outputs become, in effect, an Alternative U&T pattern which models the proposed change on specialty jobs and training flows.

Mitchell, J. L., & Lamb, T. A. (1989, November). Quantification of specialty training requirements. In the symposium, The Air Force Training Decisions System: Modeling Management and Policy Issues for Efficient Training. *Proceedings of the 31st Annual Conference of the Military Testing Association* (pp. 576-581). San Antonio, TX: Air Force Human Resources Laboratory and USAF Occupational Measurement Center.

U&T pattern simulation outputs are used to calculate the total amount of training required on those task modules each person must learn to be fully proficient in his or her job. By subtracting previous training received in technical school, field training, or self-study from the total proficiency required, the Training Proficiency (TRNPRF) program estimates the on-the-job training (OJT) hours needed on all relevant task modules for each individual to reach the required proficiency. Proposed changes in specialty jobs or training programs are modeled in terms of changes in various training requirements. TRNPRF is used to quantify the impact of changes on the total annual training requirements of the specialty being studied. TRNPRF results are then used as input data for the TDS Resource/Cost Subsystem (RCS) cost and capacity programs.

Rueter, F. H., & Feldsott, S. (1989, November). Training capacities and costs estimation for 328X4. In the Symposium (Ruck, H. W., Chair), The Air Force training decision system: Modeling management and policy issues for effective training. *Proceedings of the 31st Annual Conference of the Military Testing Association* (pp. 582-587). San Antonio, TX: Air Force Human Resources Laboratory and the USAF Occupational Measurement Center.

The Resource/Cost Subsystem (RCS) of the TDS provides capabilities to estimate the variable costs of providing the training associated with a U&T pattern, and to evaluate the capacities of different types of Air Force units to accommodate the amounts of training needed within that U&T pattern. Using the RCS, the impacts on cost and capacity that result from a change such as a 25 percent reduction in TDY-to-school funding can be assessed by comparing the cost and capacity estimates developed for the current U&T patterns and an alternative U&T pattern that models the proposed change in training flows.

Vaughan, D. S., & Bennett, W. R. (1989, November). Overview of the training decisions system: Management and policy issue development. In the Symposium (Ruck, H. W., Chair), The Air Force training decision system: Modeling management and policy issues for effective training. *Proceedings of the 31st Annual Conference of the Military Testing Association* (pp. 564-569). San Antonio, TX: Air Force Human Resources Laboratory and the USAF Occupational Measurement Center.

The Air Force Training Decisions System (TDS) is a computer-based decision support system for use by Air Force manpower, personnel and training (MPT) decision makers to evaluate training impact of various MPT policy options. In particular, the TDS models the flow of airmen through jobs in an Air Force occupation, estimates formal and on-the-job training quantities required to support job requirements, costs, and capacities. Examples of issues which can be modeled with this technology are described and evaluated.

Rueter, F. H., Feldsott, S. & Vaughan, D. S. (1989, December). *Training decisions system: Development of the resource cost subsystem* (AFHRL-TR-88-52). Brooks AFB, TX: Training Systems Division, Air Force Human Resources Laboratory.

This report contains a brief conceptual overview of the interrelationships between the Resource Cost Subsystem (RCS) and the three other major subsystems which compose the present Training Decisions System (TDS). The report highlights the novel approach undertaken and explicates the econometric and mathematical assumptions underlying the development of the model within this subsystem, including the cost analysis and capacity estimation capabilities which have been built into the RCS. These capabilities include methods for identifying training resource requirements, highlighting constraints that impede the provision of training at representative Air Force sites, and calculating variable costs for the provision of training for various training settings at representative sites. This report also summarizes data sources identified and the data collection activities performed and provides sample data collection instruments developed to obtain information for the RCS. In addition, the report examines implications from recent trends in Air Force personnel and training policy for training cost analysis. Finally, training resource cost and capacity issues are identified and recommendations for future RCS-related research activities and for using RCS products in the operational Air Force are proposed and discussed.

Lamb, T. A., Hernandez, J. M. M., & Villanueva, T. (1989). *Task clustering methodology comparison* (AFHRL-TP-88-68). Brooks AFB, TX: Training Systems Division, Air Force Human Resources Laboratory.

This report summarizes experimental work comparing task clustering methodologies in an attempt to validate the TDS task co-performance plus SME review and refinement procedures. While a number of conditions and variables were involved, the report concludes that the task coperformance clustering used in TDS does at least as well as other methodologies for grouping tasks which probably share an underlying set of common skills and knowledges.

Knight, J. R., Vaughan, D. S., Yadrick, R. M., & Bennett, W. R. (1990, April). Modeling career paths in Air Force enlisted specialties. *Proceedings of the Twelfth Psychology in the DoD Symposium* (pp. 250-254). Colorado Springs, CO: USAF Academy, Department of Behavioral Sciences and Leadership.

Present military occupational analysis methodologies focus on the identification of job types within an occupation and analysis and evaluation of initial skills training programs. New methods have recently been developed which help identify career paths including job assignment probabilities and associated training

required for job mastery. By integrating Job and Training History survey information with job analysis data, a more comprehensive model of occupational career paths can be developed. Such dynamic models of specialties represent a significant enhancement of current job analysis technology.

Chin, K. B. O., Lamb, T. A., Vaughan, D. S., Bennett, W. R. (1990). Training Decisions Modeling Technologies. *Proceedings of the Technology and Innovations in Training and Education (TITE) Annual Conference*. Colorado Springs, CO.

The Training Decisions Modeling Technology (TDMT) involves a set of baseline technologies for gathering and using information about jobs performed by airmen, personnel assignment flows, course training content, and training resources to determine training capacities of representative units and the most cost-effective training options available. The technology develops a model of a job specialty's Utilization and Training (U&T) pattern according to data collection results and simulates the flow of airmen through it. Based on this simulation, the system tabulates the costs associated with training and evaluates the training capacity of the training system (i.e., the ability of the training system to provide training to a given number of airmen). Such information should be extremely useful for Air Force decision makers, by providing a perspective on the potential outcomes of their decisions.

Vaughan, D. S., Mitchell, J. L., Knight, J. R., Bennett, W. R., & Buckenmyer, D. V. (1990, November). Developing a training time & proficiency model for estimating Air Force specialty training requirements of new weapon systems. *Proceedings of the 32nd Annual Conference of the Military Testing Association* (pp. 116-121). Orange Beach, AL: Naval Education and Training Program Management Support Activity.

Estimating training costs and training capacity constraints are among the major manpower, personnel, and training issues in the development of new weapon systems. Use of the recently developed Training Decisions Modeling Technology in the systems acquisition process is problematic since no occupational survey data will be available as a basis for modeling the specialty, its jobs, and its training. This paper reports an innovative experimental approach using subject matter experts' ratings of generic skill and knowledge categories for the anticipated work to predict training time and proficiency (training setting-specific learning curves). Regression analysis indicates that substantial proportions of the variance in training time curves can be predicted from such ratings. This approach may improve training decision making and logistic support analyses early in the new weapon system acquisition process.

Mitchell, J. L., Knight, J. R., Buckenmyer, D. V., & Hand, D. K. (1991, May). The use of CODAP in the Training Decisions System. *Proceedings of the Seventh International Occupational Analysts' Workshop* (pp. 9-18). San Antonio, TX: USAF Occupational Measurement Center.

CODAP data is used as the starting point for studies of Air Force Specialties (AFSs) in the Training Decisions System (TDS). The CODAP task clustering algorithm is used to develop task modules (TMs) for the AFS, and job types are described using summary task data at the TM level. The MODULES program permits automated calculation of statistical indices for TMs. TMs are also used as the basis for collecting additional data with which annual training requirements can be quantified and training costs and unit training capacities can be estimated, including the annual costs of AFS on-the-job training (OJT) programs. By using automated advanced CODAP analysis programs, the initial phases of a TDS study can be accomplished more cost effectively and expeditiously. In the long-term, the use of a common data base (CODAP task data) facilitates integration with other task-based systems, such as the Advanced OJT System (AOTS; now the Base-level Training System

or BTS). Such integration will also facilitate feedback to the USAFOM Squadron to enhance future task list development and improve occupational analysis processes.

Mitchell, J. L., Vaughan, D. S., Knight, J. R., Buckenmyer, D. V., & Bennett, W. R. (1991, May). An operational test of the training decisions system. *Proceedings of the Seventh International Occupational Analysts' Workshop* (pp. 274-280). San Antonio, TX: USAF Occupational Measurement Center.

An operational test of the Training Decisions System (TDS) is underway in a joint study of the Electronic Computer and Switching Systems (AFS 305X4) specialty with the USAF Occupational Measurement Squadron of Air Training Command (ATC). A brief Training and Job History Survey, developed by the TDS R&D team, is being administered with the USAF Job Inventory. Other TDS data will be gathered after the initial case and task clusters have been interpreted. TDS software is being loaded and tested on the USAFOM Sq computer to facilitate analysis of the AFS 305X4 data and to demonstrate the general utility of the system. By working closely with the USAFOM Sq during the parallel analyses of this specialty, the TDS Research & Development (R&D) team should be able to receive real-time feedback on the quality and utility of the TDS analysis, and can anticipate and resolve any problems encountered in the eventual operational implementation of the system.

Mitchell, J. L., Buckenmyer, D. V., & Hugely, H. (1991, October). Development of an integrated data base for the electronic computer and switching systems specialty (AFS 305X4). *Proceedings of the 33d Annual Conference of the Military Testing Association* (pp. 275-280). San Antonio, TX: Human Resources Directorate, Armstrong Laboratory and the USAF Occupational Measurement Squadron.

A joint study of the Electronic Computer and Switching Systems (AFS 305X4) specialty is underway through the cooperation of the USAF Occupational Measurement Squadron, Headquarters Air Training Command, and the Technical Training Research Division of the Armstrong Laboratory. A brief Training and Job History Survey, developed by the Training Decision System (TDS) R&D team, was administered along with the normal USAFOM Sq Job Inventory. Other TDS data were gathered subsequent to the interpretation of initial case and task clusters, using a common data set on the USAFOM Sq computer. TDS software was loaded and tested on the USAFOM Sq computer to facilitate this analysis, and to demonstrate the general utility of the system. The parallel occupational analysis and TDS analysis projects are both aimed at providing the AFS 305X4 Functional Manager and Utilization and Training Workshop participants with a comprehensive perspective on the specialty as well as the capability to assess the potential impacts of their decisions in terms of total training costs and AFS training capacity. By having the operational and R&D organizations work closely together to meet the real-world needs of the functional managers, this project should identify and resolve any issues critical to the possible operational implementation of the TDS technology.

Bennett, W. R., Ruck, H. W., Mitchell, J. L., & Vaughan, D. S. (1991, October). Training and organizational development in military organizations: Implications for diagnosis and needs assessment. *Proceedings of the 33d Annual Conference of the Military Testing Association* (pp. 670-675). San Antonio, TX: Human Resources Directorate, Armstrong Laboratory and the USAF Occupational Measurement Squadron.

Military organizations are, by definition, dynamic organizations. The demands placed upon them are unique and the requirements for performance are crucial for national defense. In the current fiscal environment, military organizations are experiencing unparalleled changes in personnel, mission, and structure. In this type

of environment, the capability to adequately diagnose organizational needs, and develop training methods to compensate for changes to the force structure is critical to maintaining a qualified force. This paper examines training as a strategy in organizational development. A systems approach model, based on levels of analysis, for the design of training and the identification of training and organizational objectives are discussed. The utility of a systems approach to organizational diagnosis and training development, implementation, evaluation, feedback, and refinement for continued organizational change in military organizations is critically evaluated. Finally, potential areas for future research within military contexts are highlighted.

Vaughan, D. S., Perrin, B. M., Ruck, H. W., & Bennett, W. R. (1991, October). Estimating learning curves from job analysis data. *Proceedings of the 33d Annual Conference of the Military Testing Association* (pp. 269-274). San Antonio, TX: Human Resources Directorate, Armstrong Laboratory and the USAF Occupational Measurement Squadron.

In the Air Force, occupational survey job analysis data are very useful for the front end analysis steps in the Instructional Systems Design (ISD) process. In particular, the Recommended Training Emphasis task factor provides an effective means of prioritizing tasks for training of first-enlistment airmen. However, these data do not provide direct information concerning the best training settings (e.g., classroom, self-study, hands-on, on-the-job) for training on particular tasks. We tested an occupational survey-based approach for estimating training setting-specific learning curves of task groups. Results showed that the survey responses were equivalent in reliability to those of conventional task factors and that the learning curve models fit the survey data well. These learning curves provide useful information concerning the best training settings for particular task groups. Furthermore, these curves provide a basis for estimating on-the-job training quantities, training costs and resource requirements in the Training Decisions System.

Glushko, R. J. (1991). *Training decisions modeling simulation environment: Design plan* (AL-CR-1991-01). Brooks AFB, TX: Training Research Division, Armstrong Laboratory, Human Resources Directorate.

Air Force training planners must determine the most effective and efficient ways to train people in the various Air Force Specialties (AFSSs) using formal training courses, on-the-job training, mobile training, contractor courses, and various other training options. A Training Decisions Modeling methodology is being developed by the Air Force Human Resources Laboratory (now Armstrong Laboratory, Human Resources Directorate) to provide a more integrated and unified approach for making training planning decisions. The multi-year research and development effort led by McDonnell Douglas to design and build the Training Decisions System (TDS) was the initial step in bringing together different information and trade-off requirements into an integrated decision support system. Search Technology's current project complements and builds upon the McDonnell Douglas TDS work. The project involves designing a highly interactive demonstration system that will embody more of the evolving capabilities of the Training Decisions Modeling Methodology (TDMM). This effort makes the visions and benefits of the TDMM more apparent to potential users and program supporters.

Vaughan, D. S., Knight, J. R., Mitchell, J. L., Marshall, G. A., Feldsott, S., Rueter, F. H., Hand, D. K., & Haynes, W. R. (1991, April). *Training Decisions System; Software User's Manual* (AL-CR-1991-0002). Brooks AFB, TX: Training Systems Division, Armstrong Laboratory, Human Resources Directorate.

A comprehensive description and users guide for the Training Decision System (TDS) software. This proof-of-concept system was developed in FORTRAN 77 since none of the existing commercial simulation software could provide the capacity for large numbers of variables and complex assignment probabilities. Each

TDS data file is described in terms of format and content; file naming conventions are consistent with other UNISYS files, such as the Comprehensive Occupational Data Analysis Programs or CODAP, since some TDS files are generated directly from CODAP files. [Equivalent file and program names on VAX systems, used in the software development effort, are provided in and appendix].

Chin, K. B. O., Lamb, T. A., Bennett, W. R., & Vaughan, D. S. (1992, April). *Introduction to training decisions modeling technologies: The training decision system* (AL-TP-1992-0014). Brooks AFB, TX: Technical Training Research Division, Armstrong Laboratory, Human Resources Directorate.

An introduction to the Training Decisions Modeling Technologies under development at the Armstrong Laboratory. These technologies are intended to support Air Force Training Managers by providing them with cost and resource information about the impact of their decisions on the Air Force training system. The Training Decisions System (TDS), which forms the baseline technologies for the research program, uses information about jobs performed by airmen, personnel assignment flows, course training content, and training resources to determine training capacities of representative units and the most cost-effective training options available. The TDS develops a model of a job specialty's Utilization and Training (U&T) pattern according to data collection results and simulates the flow of airmen through it. Based on this simulation, TDS tabulates the costs associated with training and evaluates the training capacity of the training system (i.e., the ability of the training system to provide training to a given number of airmen).

Mitchell, J. L., Vaughan, D. S., Knight, J. R., Rueter, F. H., Fast, J., Haynes W. R., & Bennett, W. R. (1992, June). *Training decisions technology analysis*. (AL-TP-1992-0026). Brooks AFB, TX: Technical Training Research Division, Armstrong Laboratory, Human Resources Directorate.

The Training Decisions System (TDS) is a computer-based decision support technology which has been developed to provide a more integrated approach to Air Force training planning and development. This technology was developed in an earlier research and development (R&D) effort which resulted in a proof-of-concept system. The present project examines the technologies and scientific innovations involved in the TDS both from the standpoint of separate subsystem technologies and from the viewpoint of an integrated decision support system. The procedures and software from the proof-of-concept TDS were exercised to identify problems in programs and software documentation; the problems recognized in this exercise of the system were corrected and new programs and data files created. Extensive sensitivity analyses were conducted to establish which types of variables had the greatest impact on output products (total AFS training costs and estimates of on-the-job training capacity of representative field units). Additional validation work was planned as was a study to examine the systematic biases in TDS data bases. The scientific contributions of the TDS R&D project are examined and some conclusions drawn as to how TDS relates to state-of-the-art technologies in several academic and technical areas. Finally, several potential applications of the TDS technology are recommended in terms of future training management research as well as direct application other military services and the civilian sector.

Coccia, T., Mitchell, J. L., Knight, J. R., & Shrum, R. C. (1992, October). Development of a career field training management plan for the electronic computer and switching systems specialty. *Proceedings of the 34th Annual Conference of the Military Testing Association* (pp. 831-836). San Diego, CA: Navy Personnel Research and Development Center.

A joint study of the Electronic Computer and Switching Systems specialty was undertaken by the USAF Occupational Measurement Squadron and the Technical Training Research Division of the Armstrong Laboratory, as reported at the 1991 Military Testing Association Conference. The parallel occupational analysis

and Training Decision System (TDS) studies were both aimed at assisting the AFS 305X4 Functional Manager in making critical decisions. The TDS results were used to model the current state of the specialty as well as several alternative structures proposed by an Subject-Matter Expert panel which met in May 1992. Data from both efforts will be briefed to a Utilization and Training Workshop (U&TW) for the specialty in late 1992, and the information will be used by U&TW participants to make decisions about the future course of training in the specialty. Some of the data from the occupational analysis and the TDS study were also used to draft sections of a Career Field Management Plan (CFMP), a newly-required planning document which highlights expected changes in manpower, personnel, and training programs over the next five years. A CFMP will be required of all Air Force specialties in the near future; the present study has demonstrated that both occupational analysis and TDS data can be useful in CFMP development.

Mitchell, J. L., Phalen, W. J., & Hand, D. K. (1992, October). Multilevel occupational analysis: hierarchies of tasks, modules, jobs, and specialties. In the symposium, Organizational analysis issues in the military (Ruck, H. W., chair). *Proceedings of the 34th Annual Conference of the Military Testing Association* (pp. 729-734). San Diego, CA: Navy Personnel Research and Development Center.

There are extensive amounts of task-level information now available on most military occupations which are used effectively for a variety of purposes. While detailed task-level information is critical for certain uses, such as training development or selecting topics for promotion tests, such data may be too complex and specific for other purposes; for example, for facilitating management macro-level decision making or evaluation of possible impacts of organizational restructuring. Organizing task information into task modules, jobs, and higher order categories allows the data to be applied to more global issues and problems and can be used to develop realistic models or simulations of occupational structures and requirements. Existing data already permit comprehensive organizational modeling; some present analyses involve multiple specialties, multiple categories of personnel (enlisted, officer, civilian), or even multiple services (interservice or joint service projects). Given the considerable value of task-based information and analyses, multi-level studies focused on task modules and other higher order groupings have considerable potential for applications in modeling military organizations to assist military decision makers in evaluating proposed organizational restructuring, interventions, and/or other organizational changes. This paper will highlight new ASCII Comprehensive Occupational Data Analysis Programs (CODAP) technology which permits analysis of occupational data at a number of different levels of specificity or from a variety of viewpoints. The new programs permit grouping of task-level data into meaningful clusters either statistically or on the basis of some rational organizational principle. Implications of multi-level data for simulating organizational change will be discussed.

Vaughan, D. S., Yadrick, R. M. (1992, October). An organizational analysis simulation technology. In the symposium, Organizational analysis issues in the military (Ruck, H. W., chair). *Proceedings of the 34th Annual Conference of the Military Testing Association* (pp. 735-740). San Diego, CA: Navy Personnel Research and Development Center.

One approach to addressing the quantifiable reduction in effect size which is attributable to the moderating effect of linkages is to develop a model which quantifies the contribution of changes in performance and/or productivity at one level and at other proximal level. Such a model would express important macro-level outcome variables (e.g., organizational productivity, mission effectiveness) as functions of important causal variables. These include both micro-level variables that are directly manipulated in organizational interventions and more macro-level variables, such as business and economic conditions. This type of model would be very useful for exploring the quantitative relationships among events at various levels of abstraction. Such a model could be used to determine the maximum impact that micro-level organizational interventions can reasonably be expected to have on macro-level outcome variables, relative to other uncontrolled events. This paper describes the

Training Decisions System (TDS), a simulation technology which relates events at various levels of abstraction. The model relates micro-level personnel events to macro-level outcome variables. Data for the TDS comes from a variety of sources, including job analysis, existing manpower, personnel, and training data bases, and subject-matter experts' judgments. The TDS estimates overall job flows, training requirements, and training costs from individual job, task, and training assignments, based on job analysis data. The TDS model first simulates the flow of individuals through jobs, with task performance requirements, and formal training courses. From these individual events, the model estimates task-level, on-the-job training events. Finally, the model estimates overall training resource requirements, costs, and capacities from the task-level events.

Ward, J. H., Jr., Vaughan, D. S., Mitchell, J. L., Driskill, W. E., & Ruck, H. W. (1992, October). The ultimate person-job match: a key to future worker productivity. *Proceedings of the 34th Annual Conference of the Military Testing Association* (pp. 849-854). San Diego, CA: Navy Personnel Research and Development Center.

Given current trends of decreasing budgets, reduced manpower, and escalating personnel benefits and training costs, it is imperative that the military services consider human resource policy alternatives that will enhance individual productivity and optimize personal growth and development. In the long run, a highly effective approach would be to focus on improving the match between job incumbents skills and job requirements. This approach begins with the enhancement of the kinds of information available about the jobs and the people as they enter occupations. New technologies are under development to improve the definition of what skills, knowledge, and abilities are required for each occupation; such technology could easily be extended to be job- or position-specific. Using this new technology, a better job requirements data base could be developed as the Base Training System (BTS, formerly the Advanced On-the-job Training System or AOTS) is implemented. Advanced utilization and training models, such as those developed in the Training Decisions Support Technology line of research, could be integrated as well, to help functional managers anticipate future changes in jobs and plan for possible career field transitions. Given recent developments in computers and modeling systems, the merging of all these technologies into an integrated human resources management system becomes both possible and practical. The ultimate system should be able to optimize on multiple functions so as to produce improvements in a variety of outcome variables, such as individual productivity, organizational goal achievement, personal growth and development, and classification structure stability.

Mitchell, J. L., Yadrick, R. M., & Bennett, W. R. (1993). Estimating training requirements from job and training models. *Military Psychology* 5(1):1-20.

New methods were developed for estimating the annual training requirements of individual occupations (Air Force specialties). These methods facilitate the generation of quantitative estimates of formal classroom, hands-on, self-study, and on-the-job training needed as a basis for calculating annual training requirements and for assessing the capacity of representative field units to provide such training. Using a simulation approach to estimate training requirements offers considerable flexibility for assisting decision makers in evaluating the possible impact of changes on current job structures and training programs.

Agee, R., Martino, K. B. W., Lamb, T. A., & Knight, J. R. (1993, 15 June). An operational test of OA and TIDES data for MPT decision making. In the symposium (Ruck, H. W., Chair) Military Occupational Analysis: Issues & Advances in Research and Application. *Proceedings of the Eighth International Occupational Analysis Workshop* (pp. 27-31). San Antonio, TX: USAF Occupational Measurement Squadron.

This presentation highlights the synergistic effect of combining occupational analysis (OA) technology and Training Impact Decision System (TIDES) models and methodologies. The application of OA and TIDES products to manpower, personnel and training (MPT) decision making in the recent AFS 305X4, Electronic Computer & Switching Systems, Utilization and Training Workshop (U&TW) is discussed as are specific contributions of collaborative efforts among the USAF Occupational Measurement Squadron, Armstrong Laboratory, and the R&D contractor team. Systematic feedback data (ratings and comments) from U&TW participants were gathered to evaluate the operational use of OA and TIDES information.

Bennett, W. R., Jr., Vaughan, D. S., & Ruck, H. W. (1993, June). Military occupational analysis: Future directions. In the symposium, Military occupational analysis: Issues and advances in research and application, H. W. Ruck, Chair. *Proceedings of the Eighth International Occupational Analyst Workshop* (pp. 32-36). San Antonio, TX: USAF Occupational Measurement Squadron.

This paper highlights several potential future directions in occupational analysis. Specifically, improvements to current occupational analysis practices are proposed and discussed. In addition, new uses of occupational analysis methods for such things as aggregating task-level information, dynamic modeling of organizational change, new training needs assessment activities, and deriving estimates of the cost benefit of interventions at an organizational level are discussed. Finally, several key issues related to advancing the research and development of occupational analysis methods and applications are highlighted.

Vaughan, D. S., Grimes, G. R., & Knight, J. R. (1993, November). Evaluating the impact of policies on organizations: Increasing assignment length. In the symposium, Organizational Analyses and Research: Policy Issues, Modeling, and Future Technologies, W. R. Bennett, Jr., Chair. *Proceedings of the 35th Annual Conference of the Military Testing Association* (pp. 37-42). Williamsburg, VA: U.S. Coast Guard Headquarters, Occupational Analysis Program.

This presentation highlighted the synergistic effect of using occupational analysis (OA) data to inform an organizational simulation technology for use in evaluating policy impacts on organizations. The utility of integrating OA data and organizational simulations for manpower, personnel, and training (MPT) decision making were highlighted using an actual policy issue, increasing assignment length, and simulation outcomes from recent Electronic Computer & Switching Systems and Aerospace Propulsion utilization and training workshop (U&TW) projects. The implications for an integrated approach to policy analysis were explored and evaluated.

Vaughan, D. S. & Bennett, W. R., Jr. (1993, November). Toward a unified theory of work: Organizational simulations and policy analyses. In the symposium, Organizational Analyses and Research: Policy Issues, Modeling, and Future Technologies, W. R. Bennett, Jr., Chair. *Proceedings of the 35th Annual Conference of the Military Testing Association* (pp. 31-36). Williamsburg, VA: U.S. Coast Guard Headquarters, Occupational Analysis Program.

The military environment is constantly changing and restructuring. MPT planning and management is increasingly crucial to maintaining the mission readiness of the forces. The DoD needs an integrated MPT planning and management system. We believe that a unified theory of work is needed to provide a framework and to guide and focus related R&D. This unified theory of work will connect theories of human traits and states, theories of task and job characteristics, theories of job/task performance, and perhaps theories of organizational behavior. For example, Mitchell & Driskill (1986) have proposed a theory that relates training to task performance, via a series of intervening and exogenous variables. Such a theory could be extended to encompass individual differences among workers and tasks, as well as key organizational and environmental variables. This

presentation will explore key issues associated with a unified theory approach to MPT modeling and decision making. Further, basic research and development needs required for such an integrated approach will be highlighted and discussed.

Ward, J. H., Jr., Mitchell, J. L., Weissmuller, J. J., & Vaughan, D. S. (1993, November). A software system for modeling jobs and people characteristics to help optimize individual and organizational objectives. In the symposium, Organizational Analyses and Research: Policy Issues, Modeling, and Future Technologies, W. R. Bennett, Jr., Chair. *Proceedings of the 35th Annual Conference of the Military Testing Association* (pp. 25-30). Williamsburg, VA: U.S. Coast Guard Headquarters, Occupational Analysis Program.

There is a critical need for the development of a general utility software package which would permit both policy capturing and policy specifying analyses through modeling of individual people characteristics and job properties. Such software should be functional at multiple levels of abstraction: at an operational level, for person-job matching, and at an organizational planning level for executive assessment of alternative strategies for mission accomplishment or adaptation to changes. Planners and decision-makers need to be able to evaluate optimal ways of allocating available people to existing or anticipated work, and individuals need to order their preferences based on available or expected work and possible training. The needed software system would extend traditional person-job match technology to become a multi-level simulation and analysis system which could be potentially very useful in fuzzy budgeting or programming, and in planning for military to civilian conversions (individuals, units, bases, etc.). We strongly advocate an expeditious research & development effort for the design and tryout of such a software system.

Stone, B., Weissmuller, J.J., & Mitchell, J.L. (1995, May). Occupational analysis data and MPT - related research and development. In the symposium, Military occupational analysis: Research and application for manpower, personnel, and training, A.M. Smith, II & W. Bennett, Jr., Chairs. *Proceedings of the Ninth International Occupational Analyst Workshop* (pp.19-26). San Antonio, TX: Air Force Occupational Measurement Squadron.

A number of research and development (R&D) contracts are currently underway which make use of occupational survey data for a wide variety of purposes at varying levels of specificity and organizational structure. Since all of these projects use task-based occupational analysis as a starting point, most of the technologies are highly compatible and can work synergistically; they could easily be integrated into an overall military MPT support system to deal with a wide range of decision making, manpower modeling, personnel classification specification, training development and evaluation, MPT systems operation, research and development, and organizational productivity enhancement activities. Some of these evolving technologies, such as RISC-based CODAP, computer-based surveying, improved job and task clustering, training impact decision support (i.e., TIDES), and organizational modeling hold substantial promise to greatly enhance the value and usefulness of military occupational analysis programs.

Bennett, T., Zukor, K., Teachout, M.S., Smith, A.M. II, & Bennett, W., Jr. (1995, May). Occupational analysis data and training-related research and development. In the symposium, Military occupational analysis: Research and application for manpower, personnel, and training, A.M. Smith, II & W. Bennett, Jr., Chairs. *Proceedings of the Ninth International Occupational Analyst Workshop* (pp.64-68). San Antonio, TX: Air Force Occupational Measurement Squadron.

Current education and training research focuses on macro issues related to modeling and planning jobs and training flow for entire career fields, and more micro issues related to the knowledge, skills, abilities, and

tasks associated with training and job performance. Current research and development which addresses a number of more macro issues in training and education needs assessment and evaluation is the Training Impact Decision System (TIDES). Similarly, the Training Efficiency and Effectiveness Methodology (TEEM) is designed to address more micro issues. Recent activities from each of these major efforts were discussed in terms of how they capture and portray occupational analysis data for use in career field decision making and for course development and revision.

Agee, R., Martino, K.B.W., Lamb, T., & Knight, J.R. (1995, August). An operational test of OA and TIDES data for MPT decision-making. In *Military occupational analysis: Issues and advances in research and application*, W. Bennett, Jr., & J. L. Mitchell, Editors (AL/HR-TR-1995-0131; pp. 34-44). Brooks AFB, TX: Technical Training Research Division, Armstrong Laboratory Human Resources Directorate.

The Armstrong Laboratory/Human Resources Directorate (AL/HR) conducted an operational test of the Training Impact Decision System (TIDES; previously the Training Decisions System) in conjunction with a contracting team led by McDonnell Douglas Aerospace. Occupational analysis (OA) expertise and operational support were provided by the Air Force Occupational Measurement Squadron (AFOMS). This operational test was highly successful; TIDES can be used to dynamically model the long-term personnel and training issue impacts on an AFS for various combinations of training content, sites, and proposed policy changes within the training system. TIDES is a powerful methodology to aid key decision-makers at the MAJCOM and USAF levels in determining the optimal utilization of resources necessary to support the mission of an AFS.

Bennett, W., Jr., Vaughan, D.S., & Ruck, H.W. (1995, August). Military occupational analysis: Future directions. In *Military occupational analysis: Issues and advances in research and application*, W. Bennett, Jr., & J. L. Mitchell, Editors (AL/HR-TR-1995-0131; pp. 45-55). Brooks AFB, TX: Technical Training Research Division, Armstrong Laboratory Human Resources Directorate.

Typically, job analysis data are used to portray the current state of tasks within jobs in an organization for the analysis of personnel recruitment, selection, placement, training and development, and performance appraisal. There are key areas of opportunity for future research in occupational analysis and application. These include improvements to existing OA practice and extending current occupational modeling for multilevel analysis and dynamic organizational modeling. A unified theory of work is needed to provide a framework for future R&D and to guide and focus future OA applications.

Mitchell, J.L., Knight, J.R., Luster, C., Stone, B., Turner, K., Hand, D., Smith, A.M., II, Bennett, T. (In Press). Implications of using mixed civilian-military samples in developing career field education and training plans. In the symposium, *Issues and advances in task-based occupational research and development for manpower, personnel, and training*, R. B. Gould, Chair. *Proceedings of the 37th Annual Conference of the International Military Testing Association*. Toronto, Ontario, Canada: Canadian Forces Personnel Applied Research Unit, October 1995.

An occupational analysis of the Pavements Maintenance and Construction Equipment specialty included both Air Force military and civilian personnel; this study provided the opportunity to conduct, for the first time, a joint study utilizing the Training Impact Decision System (TIDES) with civilian employees. The impact of including civilians in the study on task and job clusters was assessed, as well as broader issues of TIDES data collection or estimation. The five civilian series involves were differently represented in the sample which complicates modeling of job and training probabilities, as is required for the estimation of total annual costs for training. The study is on-going, with final results due early in 1996 when a Utilization and Training Workshop

for this specialty will be convened to develop a career field education and training plan (CFETP) using the CFETP template available in TIDES.

Stone, B, Turner, K., & Curry, G. (In Press). Determining the representativeness of outcomes for an entity-based training simulation model. In the symposium, Using occupational information for organizational analysis: Issues and recent applications, R. M. Yadrack, Chair. *Proceedings of the 37th Annual Conference of the International Military Testing Association*. Toronto, Ontario, Canada: Canadian Forces Personnel Applied Research Unit, October 1995.

A recent research effort focused on developing a methodology to determine the optimum time period for stopping a time-series entity based simulation; this work was conducted using the Training Impact Decision System (TIDES) which is an entity-based job and training simulation model. The primary objective was to obtain and insure representative outcomes from the simulation for baseline and alternative scenario simulations. Mathematical equations for the identification of the optimum time period for stopping the simulation were developed and imbedded into the TIDES modeling system. These equations were also used to determine the number of repetitions required to insure representativeness of transition periods for policy changes implemented in alternative applications. Confidence intervals were developed for outcome values of the simulation for comparison of steady state and transition period outcome values.

Bennett, W., Jr., Perrin, B., & Yadrack, R.M. (In Press). Using organizational simulations to estimate the utility of interventions and change. In the symposium, Using occupational information for organizational analysis: Issues and recent applications, R. M. Yadrack, Chair. *Proceedings of the 37th Annual Conference of the International Military Testing Association*. Toronto, Ontario, Canada: Canadian Forces Personnel Applied Research Unit, October 1995.

Recently there has been considerable interest in the use of computer simulations to examine the impact of organizational interventions and to quantify the effects of moderators by making relationships between these interventions and multilevel outcomes explicit. The potential uses of an organizational simulation were examined for (a) minimizing requirements for additional training as a result of new personnel assignments; and (b) estimating the requirements for additional training, providing a measure of training utility, expressed as changes in costs, changes in proficiency, and the impact of training requirements on available training resources. In addition, recent results from the use of the simulation to assess the utility of change from job restructuring/reorganization and changes to training course content and delivery methods were also discussed.

## APPENDIX B - TDS/TIDES: PRESENTATIONS \*

- Archer, W. B. (1985, May). The training decision system: Background. Presentation to the 5th Annual Conference of the National Security Industrial Conference on Personnel and Training Factors in Systems Effectiveness, San Antonio, TX.
- Vaughan, D. S. (1985, May). The training decisions system. Presentation to the 5th Annual Conference of the National Security Industrial Conference on Personnel and Training Factors in Systems Effectiveness, San Antonio, TX.
- Ruck, H. W., & Mitchell, J. L. (1987, April). Integration of training R&D into the USAF Manpower-Personnel-Training system. Presentation to the Second Annual Midyear Conference of the Society of Industrial and Organizational Psychology, Atlanta, GA.
- Collins, D. L. & D. S. Vaughan (1987, April). Development of a training decisions system. Presentation to the Second Annual Midyear Conference of the Society of Industrial and Organizational Psychology, Atlanta, GA.
- Collins, D. L., Vaughan, D. S., & Ruck, H. W. (1987, August). Application of microcomputers in the development and evaluation of R&D projects. Presentation to the American Psychological Association Annual Convention, Washington, D.C.
- Rueter, F. H. (1987, September). Training cost estimation in the training decisions system: Methodology, data sources, and data analysis plans. Presentation to the Department of Defense Cost Analysis Symposium, Washington, D.C.
- Mitchell, J. L., Vaughan, D. S., Yadrick, R. M., Collins, D. C., & Hernandez, J. M. (1988, April). The Air Force training decisions system: Modeling job and training flows. Presentation in the Symposium, Recent Developments in Air Force Training Research (Ruck, H. W., Chair). Third Annual Midyear Conference of the Society of Industrial and Organizational Psychology, Dallas, TX.
- Vaughan, D. S., Rueter, F. H., & Bennett, W. R. (1989, June). Training decision system: Evaluating training impacts of manpower, personnel, and training policies. Operations Research Society Symposium, Fort Levenworth, KS.
- SYMPOSIUM (H. W. Ruck, Chair), Decisions Support Systems For Training: Interdisciplinary Perspectives, American Psychological Association Annual Convention, New Orleans, LA, August 1989:
- Lamb, T. A., & Vaughan, D. S. Overview of the training decisions: Results and products.
- Bennett, W. R., & Perrin, B. The task characteristics subsystem: Allocating task modules to training settings.
- Mitchell, J. L., & Yadrick, R. M. The field utilization subsystem: Job and training pattern simulations.
- Rueter, F. H., & Feldsott, S. Resource/cost subsystem: Estimating training capacities and costs.

\* Does not include those presentations included in a *Proceedings* or other publication listed earlier.

Vaughan, D. S., and Eschenbrenner, A. J. Integration/optimization subsystem: An integrated modeling approach.

Discussant: Ford, J. Kevin, Department of Psychology, Michigan State University.

Buckenmyer, D. V., Worthington, K., Vaughan, D. S., & Mitchell, J. L. (1991). Research & development to support Air Force career field management planning. 1991 Interservice/Industry Training Systems Conference, Orlando, FL.

Rueter, F. H., Perrin, B., Mitchell, J., Bennett, W. R., & Grimes, G. (1994, 23 April). The training impact decision system (TIDES): A decision-aiding system for personnel utilization and training in U. S. Air Force occupational specialties. Presentation to the Mathematical and Computational Organization Theory Workshop, The Institute of Management Science/Operations Research Society of America, Boston, Massachusetts.

Grimes, G. R., Wimpee, W. E., Bennett, W. R., and Mitchell, J. L. (1994, September). Training impact decision system. Presentation to the 1994 Symposium on Human Interaction on Complex Systems. North Carolina A&T State University, Greensboro, NC.